

REMARKS

The present application is directed to improvements in the X-ray fluorescence thickness tester disclosed in U.S. Patent No. 6,522,718.

In order to place this application in condition for a complete action on the merits, the specification has been suitably revised to correct informalities and to place it in better conformance with U.S. practice. Proposed drawing revisions have been submitted in Figs. 1, 2 and 5 to add missing reference numeral lead lines. A new abstract which more clearly reflects the invention to which the amended and new claims are directed has been substituted for the original abstract.

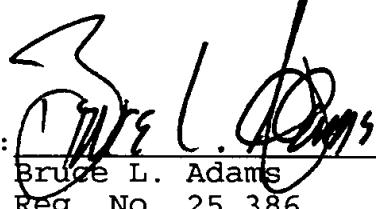
Original claims 1-4 have been amended in formal respects to improve the wording and bring them into better conformance with U.S. practice. To obtain a fuller scope of coverage, new claims 5-26 have been added. Adequate support for the subject matter recited in these claims may be found in the specification as originally filed.

Attached hereto is a marked-up version of the changes made to the abstract, specification and claims by the current amendment. The attached pages are captioned "VERSION WITH MARKINGS TO SHOWN CHANGES MADE."

Early and favorable action on the merits are respectfully requested.

Respectfully submitted,
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MAILING CERTIFICATE

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ABSTRACT OF THE DISCLOSURE

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An X-ray fluorescence film thickness measuring device has an X-ray generating system generating and irradiating primary X-rays. A focusing system focuses primary X-rays irradiated from the X-ray generating system onto microscopic measurement regions in a sample. A sample observation optical system is used to observe the sample during focusing of the primary X-rays for use in positioning of the microscopic measurement regions relative to the primary X-rays. A first sensor with low counting efficiency but high energy resolution detects X-ray fluorescence generated from a sample having the microscopic measurement regions. A second sensor has low energy resolution but high counting efficiency compared to the first sensor. Each of a pair of pre-amplifiers receives a signal from a respective one of the first and second sensors.

ALL

"VERSION WITH MARKINGS TO SHOW CHANGES MADE"

IN THE ABSTRACT:

The original abstract has been replaced with the following new abstract:

An X-ray fluorescence film thickness measuring device has an X-ray generating system generating and irradiating primary X-rays. A focusing system focuses primary X-rays irradiated from the X-ray generating system onto microscopic measurement regions in a sample. A sample observation optical system is used to observe the sample during focusing of the primary X-rays for use in positioning of the microscopic measurement regions relative to the primary X-rays. A first sensor with low counting efficiency but high energy resolution detects X-ray fluorescence generated from a sample having the microscopic measurement regions. A second sensor has low energy resolution but high counting efficiency compared to the first sensor. Each of a pair of pre-amplifiers receives a signal from a respective one of the first and second sensors.

IN THE SPECIFICATION:

The following heading has been inserted in page 1 between lines 1 and 2 after the title:

Field of the Invention

Paragraph beginning at line 2 of page 1 has been amended as follows:

The present invention relates to an energy dispersion type fluorescent X-ray type thickness measurement device having the merits of being both multi-elemental and non-destructive[,] and being for use in film thickness management in [fields of] the surface processing industry such as the plating and sputtering of films.

The following heading has been inserted on page 1 between lines 7 and 8:

Background Information

Paragraph beginning at line 1 of page 2 has been amended as follows:

Fig. 5 shows an example of a related art fluorescent X-ray film thickness measuring device. A high voltage is applied from an X-ray generation high voltage source 1.

Primary X-ray 3 emitted from an X-ray tube 2 are then irradiated onto a sample 5 by means 4 for focusing onto a microscopic unit using a slit, collimator, or capillary utilizing a total reflection phenomena. A sample observation mirror 6 and a sample observation optical system 7 are provided for positioning of the measurement locations by movement of the sample through control of a stage 19 by a control and computing section 17. Fluorescent X-rays [6] 8 generated by the sample are detected by an energy dispersion-type sensor 9. A pre-amplifier 10 is provided to receive an output of the sensor 9. A pre-amplifier 10 is provided to receive an output of the sensor 9 and a linear amplifier 11 receives the output of the pre-amplifier, which is supplied to a frequency analyzer (MCA) 12 with an output signal thereof being quantitatively processed by a control and computing section 17.

Paragraph beginning at line 9 of page 3 has been amended as follows:

Conventionally, a proportional counter tube is typically employed when carrying out film thickness measurements on thin films using a fluorescent X-ray film thickness measurement device. Accurate film thickness and composition measurements are possible without performing special processing [providing] provided that the atomic

numbers of the elements making up the thin film and materials (substrate) are separable to a certain extent when using a proportional counter tube. However, when the atomic numbers are separated into the neighboring nickel ($Z=28$) and zinc ($Z=29$), there is a problem that the peaks to be counted overlap with each other, which needs to be remedied. For example, there is a secondary filtering method whereby a thin plate of cobalt ($Z=27$) is inserted prior to detection and peak separation is achieved by utilizing the difference in results for absorption of copper, and a digital filtering method which provides a peak separation by performing numerical operation on the shapes of the peaks. The secondary filtering is limited to appropriate combinations. This is therefore effective in the case of dedicated function but is not appropriate in cases where the object is to take measurements for various combinations. The digital filtering method is capable of being applied to various combinations but there are problems with stability compared with secondary filtering methods that accompany peak separation errors.

Paragraph beginning at line 12 of page 6 has been amended as follows:

According to the present invention, counting
[Counting] is performed simultaneously using a two system X-ray detector by dividing the energy regions in such manner

that a PIN diode detector of superior energy resolution is utilized for low energy regions where X-ray energies are close to each other and [utilizing] a proportional counter tube or CdZnTe detector with a superior count rate but with poor resolution for high energy regions is utilized when the [where] count rate is poor [with a] using the PIN diode detector [but where] high resolution is not required.

Heading at line 3 of page 8 has been amended as follows:

DETAILED DESCRIPTION OF THE PREFERRED [EMBODIMENT]
EMBODIMENTS

Paragraph beginning at line 12 of page 8 has been amended as follows:

At the time of irradiation, since measurement regions are microscopic, a sample observation mirror 6 and a sample observation optical system 7 are provided for positioning of the measurement locations by movement of the sample 5 through control of a stage 19 by a control and computing section 17. Fluorescent X-rays 8 generated by the sample are positioned in such a manner as to be detected by an energy dispersion-type first sensor 9 and a second sensor 13. A sensor 13 characterized by high resolution, for example a PIN diode detector or a high resolution X-ray detector such as a silicon drift chamber, is provided at an energy dispersion-type X-ray detector. When a PIN diode detector is utilized in

the sensor 13, resolution (FWHM) with respect to the Mn-K_a line (5.9keV) is in the order of 200eV, and the count rate is in the order of a few tens of thousands cps. However, this is used as a low energy detector due to the detection rate for high energy X-rays being poor. When a proportional counter tube is used as the sensor 9, the resolution is in the order of 1keV and the count rate can be in the order of a few tens of thousands of cps. When a scintillation counter is used, the resolution is poor at a few keV, but a counter rate of a few hundred thousand cps is possible.

IN THE CLAIMS:

Claims 1-4 have been amended as follows:

1. (Amended) An X-ray fluorescence film thickness measuring device comprising:

[a high-voltage supply for exciting fluorescent X-rays;]

an X-ray generating system [constituted by] having a high-voltage power source and an X-ray tube for irradiating primary X-rays;

focusing means for focusing primary X-rays [emitted] irradiated from the X-ray generating system onto [a] microscopic measurement regions in a sample [part] using a slit unit, a collimator, or a capillary unit utilizing [the] a total reflection phenomenon;

a sample observation optical system for observing the sample during focusing of the primary X-rays for use in positioning of the microscopic measurement regions relative to the primary X-rays; [deciding a position of a measuring position of a measuring region on the microscopic part; and]

a system having a liquid nitrogen-less PIN diode X-ray detector or a silicon drift chamber used as a first sensor with low counting efficiency but high [having superior operability due to being liquid nitrogen-free taken as a first sensor with a low count rate but having superior] energy resolution for detecting X-ray fluorescence generated from the sample, and [X-rays emitted from a target sample,] a proportional counter [tube], CdZnTe detector, or a scintillation counter [taken] as a second sensor [counter] having low [poor] energy resolution but high counting efficiency [superior count rate with respect to high energy] compared [with] to the first sensor, the first and second sensors being arranged side-by-side in a [juxtaposed in a atmospherically open type] sample chamber that is open to the atmosphere and not evacuated, and the system being divided between the first and second sensors [not vacuum-evacuated, with this system allotting two types of detector] according to [the] energy of X-ray fluorescence [the fluorescent X-rays] by utilizing the first sensor for X-ray fluorescence from [fluorescent X-rays of] low energy and utilizing the second

sensor for X-ray fluorescence from high energy; [fluorescent X-rays of high energy, wherein the latter stage of each detector consists of separate pre-amplifiers, linear amplifiers and wave analyzers, and with quantitative processing being carried out at common control and computing sections.]

a pair of pre-amplifiers each for receiving a signal from a respective one of the first and second sensors;

a pair of linear amplifiers each for receiving a signal from a respective one of the pre-amplifiers;

a pair of frequency analyzers each for analyzing a frequency of a signal from a respective one of the linear amplifiers; and

common control and computing sections for quantitatively processing signals from the frequency analyzers.

2. (Amended) An X-ray fluorescence film thickness measuring device comprising:

[a high-voltage supply for exciting fluorescent X-rays;]

an X-ray generating system [constituted by] having a high-voltage power source and an X-ray tube for irradiating primary X-rays;

focusing means for focusing primary X-rays [emitted] irradiated from the X-ray generating system onto [a]

microscopic measurement regions in a sample [part] using a slit unit, a collimator, or a capillary unit utilizing [the] a total reflection phenomenon;

a sample observation optical system for observing the sample during focusing of the primary X-rays for use in positioning of the microscopic measurement regions relative to the primary X-rays; [deciding a position of a measuring position of a measuring region on the microscopic part; and]

a system having a liquid nitrogen-less PIN diode X-ray detector or a silicon drift chamber used as a first sensor with low counting efficiency but high [having superior operability due to being liquid nitrogen-free taken as a first sensor with a low count rate but having superior] energy resolution for detecting X-ray fluorescence generated from the sample, and [X-rays emitted from a target sample,] a proportional counter [tube], CdZnTe detector, or a scintillation counter [taken] as a second sensor [counter] having low [poor] energy resolution but high counting efficiency [superior count rate with respect to high energy] compared [with] to the first sensor, the first and second sensors being arranged side-by-side in a [juxtaposed in a atmospherically open type] sample chamber that is open to the atmosphere and not evacuated, and the system being divided between the first and second sensors [not vacuum-evacuated, with this system allotting two types of detector] according to

[the] energy of X-ray fluorescence [the fluorescent X-rays] by utilizing the first sensor for X-ray fluorescence from [fluorescent X-rays of] low energy and utilizing the second sensor for X-ray fluorescence from high energy; [wherein the latter stage of each detector as far as the pre-amplifiers consists of separate pre-amplifiers, a wave analyzer function is performed collectively by a single digital circuit, and quantitative processing is carried out at common control and computing section.]

a plurality of pre-amplifiers each for amplifying a signal from respective ones of the first and second sensors;

a single digital circuit for amplifying and analyzing frequencies of signals from the pre-amplifiers; and
common control and computing sections for
quantitatively processing signals from the single digital circuit.

3. (Amended) A fluorescent X-ray film thickness measuring device comprising:

[a high-voltage supply for exciting fluorescent X-rays;]

an X-ray generating system [constituted by] having a high-voltage power source and an X-ray tube for generating and emitting primary X-rays;

focusing means [for focusing primary X-rays emitted from the X-ray generating system onto a microscopic part using

a collimator;] including a first collimator block for focusing the primary X-rays onto microscopic measurement regions in a sample and a second collimator block disposed above the first collimator block for receiving the primary X-rays from the X-ray generating system and irradiating the X-rays toward the first collimator block;

a sample observation optical system for observing the sample during focusing of the primary X-rays for use in positioning of the microscopic measurement regions relative to the primary X-rays; [deciding a position of a measuring position of a measuring region on the microscopic part;]

a detector for detecting X-ray fluorescence [fluorescent X-rays] generated from [by] the sample;

a pre-amplifier for amplifying a signal from the detector;

a linear amplifier for amplifying a signal from the pre-amplifier; and

a frequency analyzer for analyzing a frequency of a signal from the linear amplifier. [a wave analyzer, wherein the collimator for a system for performing quantitative processing using a control unit and computing section is configured from a first collimator block for focusing onto the microscopic part and a second collimator block for emitting X-rays at a normal size located above the first collimator block.

4. (Amended) [The] A fluorescent X-ray film thickness measuring device according to claim 3; [for claim 3,] wherein the first collimator block comprises a half mirror section and a collimator section located at a side surface of the half mirror section, and the second collimator block comprises a plurality of collimator units located in order along a lateral direction, the first collimator block and the second collimator block being movable in a direction generally perpendicular to an optical axis of the primary X-rays; [can be moved in a lateral direction,] and further comprising an arbitrary collimator section or half mirror section disposed [can be located] at a position along [the] an optical axis of the first and second collimator blocks.